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DEPARTMENT OF MINES.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES,

C. S. WILKINSON, F.G.S., &c., GEOLOGICAL SURVEYOR-IN-CHARGE.

PALÆONTOLOGY, NO. 1.

THE INVERTEBRATE FAUNA

OF THE

HAWKESBURY—WIANAMATTA SERIES

(BEDS ABOVE THE PRODUCTIVE COAL-MEASURES)

OF

NEW SOUTH WALES.

BY

ROBERT ETHERIDGE, Jnr.

(Palæontologist to the Geological Survey, Department of Mines; and Australian Museum, Sydney).

ISSUED BY DIRECTION OF THE HON. FRANCIS ABIGAIL, M.P., MINISTER FOR MINES.

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Department of Mines,
Geological Survey Branch,
Sydney, 22 September, 1888.

Sir,

I have the honor to submit the accompanying Memoir on the *Invertebrate Fauna of the Hawkesbury-Wianamatta Series (beds above the productive Coal-Measures) of New South Wales*, by Mr. Robert Etheridge, Junior, Palæontologist.

The Wianamatta, Hawkesbury, and Narrabeen rocks constitute, as you are aware, extensive formations in the eastern central portion of this Colony, and are well represented in the district of Sydney. They may be regarded as the uppermost members of the great coal-bearing group which ranges down to the Lower Carboniferous.

The elucidation, therefore, of the Palæontology of this series is of much interest in the determination of this important geological horizon, which appears to be homotaxial with the Trias of the Northern Hemisphere.

This Memoir is the first of the Palæontological series of the Geological Survey of New South Wales. The second, on *The Tertiary Flora of Australia*, by Baron C. von Ettingshausen, is now in the hands of the Government Printer, and will soon be issued. Almost ready for the press (the illustrations are already printed) is the recently revised work of Dr. Ottokar Feistmantel on the *Geological and Palæontological Relations of the Coal and Plant-bearing beds of Palæozoic and Mesozoic Age in Eastern Australia and Tasmania, with special reference to the Fossil Flora;* also a translation of the late Professor de Koninck's *Recherches sur les Fossiles Paléozoïques de la Nouvelle-Galles du Sud.*

Mr. A. S. Woodward, F.G.S., &c., Assistant in the Geological Department, British Museum, has kindly undertaken the description of our fine collection of Fossil Fish from the Hawkesbury-Wianamatta Series.

The publication, in a form accessible to the general public, of these Memoirs, with others now in course of preparation by Mr. Etheridge, will not only afford valuable works of reference for students and those interested in Australian Geology, but must also indirectly foster the development of our varied mineral resources which the geological formations of this Colony indicate to be so extensive.

The first Memoir of the Geological Series—*Geology of the Vegetable Creek Tin-mining Field, New England District, with Maps and Sections,* by Mr. T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor; also *Mineral Products of New South Wales,* by Mr. Harrie Wood, Under Secretary for Mines; *Notes on the Geology of New South Wales,* by myself; and *Description of the Seams of Coal worked in New South Wales,* by Mr. John Mackenzie, F.G.S., Examiner of Coal-fields, have already been published.

I have the honor to be,
Sir,
Your obedient Servant,

C. S. WILKINSON,
Geological Surveyor-in-Charge.

HARRIE WOOD, ESQ.,
Under-Secretary for Mines.

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INVERTEBRATE FAUNA OF THE HAWKESBURY-WIANAMATTA SERIES.

I.—INTRODUCTION.

THE remains of Invertebrata described in the present Memoir are from a series of beds of considerable thickness above the productive Coal-Measures of New South Wales. They appear divisible into four well-marked lithological subdivisions, and which, so far as at present known, are conformable with one another. Proceeding from above downwards, the beds in question are—

1. *Wianamatta Shales*, about 700 feet thick *(Clarke)*.
2. *Hawkesbury Sandstone* (Sydney Sandstone of Dana and Jukes), about 1,000 feet thick *(Wilkinson)*.
3. *Narrabeen Shales*, about 650 feet thick *(David)*.
4. *Estheria Shales*, about 640 feet thick *(David)*.

Many good natural sections of the two first subdivisions are in existence, but the third and fourth have chiefly been investigated by means of the Diamond Drill in borings made for coal.

The principal bores, and those more particularly referred to hereafter, are the following:—

1. Moore Park Bore, about half a mile south of Baptist's Gardens, Bourke-street, Surry Hills, Sydney; depth, 1,860 feet.
2. Botany Bore, on the Holt-Sutherland Estate, Port Hacking; depth, 2,200 feet.*
3. Dent's Creek Bore, on the Holt-Sutherland Estate, George's River; depth, 2,307 feet.†
4. Heathcote Bore, near Mount Westmacott; depth, 1,585 feet.‡
5. Liverpool Bore, George's River, about 4 miles south of Liverpool.
6. Narrabeen Bore, near Long Reef, north of Manly; depth, 1,980 feet.

* For Journal, see Mineral Products, New South Wales, second edition, 1887, pl. 6.
† For Journal, see Annual Report, Department of Mines, New South Wales, for 1883 [1884], p. 197, and 1886 [1887], p. 189.
‡ For Journal, see *ibid.*, for 1885 [1886], p. 176.

The Wianamatta Shales consist chiefly of argillaceous shales, deposited in the denuded hollows and on the worn surfaces of the Hawkesbury Sandstone. The remains of plants, fish, and traces of Labyrinthodonts have been found in them. The late Rev. W. B. Clarke, F.R.S., estimated the thickness of this series to be about 700 feet.

The Hawkesbury Sandstones are described by Mr. C. S. Wilkinson, F.G.S., as "yellowish-white sandstones, with a few beds of shale and pebble conglomerates of irregular thickness." Plants and fish are plentifully met with, and two Labyrinthodonts have been described from this series—one believed to be identical with the European Triassic *Mastodonsaurus robustus*,* and another named *Platyceps Wilkinsoni*, Stephens.† The Hawkesbury Sandstone in the Berrima District rests directly on the Coal-Measures, but at Coal Cliff there is an intermediate set of beds 869 feet thick.‡ These are included in the succeeding group. The entire thickness of the Hawkesbury Series is estimated by Mr. Wilkinson to be 1,000 feet.

The Narrabeen Shales, which may perhaps be the equivalents of the Clarence Series, consist of purplish-red or chocolate ferruginous clay-shales. They are visible in cliff section at Long Reef, to the north of Manly, but have, however, been studied more in detail from the core of the Holt-Sutherland Bore at Dent's Creek. Here they were struck, according to Mr. T. W. E. David, at a depth of 771 feet below the surface, and extended to that of 1,362 feet, giving a thickness of 591 feet.

The Estheria Shales follow below the Narrabeen in the above bore, from 1,462 feet to 2,000 feet, or, in round numbers, a thickness of 638 feet. They consist of fine greenish-gray shales and dark grey mudstones, with 71 feet of purple and green-mottled cupriferous shale and tuff. The true Coal Measures are believed by Mr. David to appear at a depth of 2,000 feet.

Taking the Holt-Sutherland Bore at Dent's Creek as a typical section of the infra-Hawkesbury strata, Mr. David remarks§ that it "does not afford any evidence of unconformity from the coal seams upwards, through the so-called passage beds, into the Hawkesbury Sandstone." He adds—"Stratigraphical evidence derived from a core $1\frac{1}{2}$ inch in diameter is obviously not very reliable; but, so far as it may be accepted, shows no break in the

* Stephens, Proc. Linn. Soc., New South Wales, 1886, I, pt. 3, p. 931.
† Proc. Linn. Soc., New South Wales, 1887, II, pt. 1, p. 156.
‡ Notes on the Geology of New South Wales, Department Mines, second edition, 1887, p. 74.
§ MS. Report.

sequence of strata from the top of the upper coal seams to the top of the Hawkesbury Series. Lithological evidence shows that there is a break between the Narrabeen beds and the Estheria beds. On the whole, the latter seem lithologically more related to the underlying Coal-Measures than to the Hawkesbury beds."

With the view of fully illustrating the sparsely scattered Invertebrate remains found in this consecutive series of deposits, the Estheria beds are provisionally included here.

The meagreness of this fauna renders the occurrence of any animal remains, however small, or poorly preserved, of the highest importance, whether it be regarded as throwing light upon the age of the rocks in question, or their mode of deposition.

In the fourth edition of the late Rev. W. B. Clarke's *Sedimentary Formations of New South Wales*, published in 1878, the fossils of the Hawkesbury-Wianamatta Series mentioned, consisted wholly of plants and fish. The first published addition to this list was Dr. J. C. Cox's announcement of the discovery of *Estheria* in the Moore Park and Port Hacking bores. To this little fossil Dr. Cox gave the name of *Estheria Coghlani*,* after Mr. John Coghlan, of the Australian Diamond Drill Company, under whose directions the Moore Park Bore was sunk; but Dr. Cox did not publish a description of it. The *Estheria* was first met with at a depth of 1,523 feet, in dark shaly partings, in a hard 30-foot sandstone, and occurred at intervals as low as the bore was prosecuted, extending through a thickness of 337 feet. It is quite clear from these measurements that *E. Coghlani* is here wholly confined to Mr. David's Estheria-shale. In the Port Hacking bore *Estheria* was not found, Dr. Cox says, until a depth of 2,160 feet had been attained, but "in exactly the same character of shaly rock."

In the bore-cores at Dent's Creek *Estheria* was discovered by Mr. T. W. E. David, at a depth of 1,362, and again at 1,625 feet, in dark, sandy clay shales. The fossil was again observed in a siliceous clay shale at 1,651 feet. These horizons are, respectively, 866 and 603 feet, and 577 feet above the highest coal struck in the bore. At the still greater depths of 1,932 feet and 2,000 feet respectively, valves of a larger form were found. Up to the year 1882, therefore, when Mr. C. S. Wilkinson's "Notes on the Geology of New South Wales"† appeared, *Estheria* was the only Invertebrate fossil discovered in this great thickness of beds.

* First edition, p. 54, 4to., Sydney (Department of Mines), 1882.

In the bore at Heathcote the *Estheria* valves were found by Mr. C. S. Wilkinson, F.G.S., but only on one horizon, a bed of shale at 1,009 feet from the surface, and about 504 feet above the highest seam of coal struck at that locality.

The bore recently put down at Narrabeen by Mr. Coghlan is said by that gentleman to have reached a depth of 1,980 feet odd. We have been favoured by him with two examples of *Estheria*, from a depth of 1,961 feet, but the general features of the strata passed through have not yet been made public.

The bore on the Moorbank Estate, George's River, near Liverpool, appeared to Mr. T. W. E. David and the writer, during a recent inspection, to have started at or about the junction of the Wianamatta Shales and the Hawkesbury Sandstone. At the time of our visit the boring operations were in abeyance, but as near as could be ascertained, a depth of about 1,080 feet had been reached. The lowest portion of the core presented all the appearance of the Narrabeen Shales, but no evidence of the drill having reached the Estheria Shales presented itself.

The following table shows in abstract the depth from the surface at which the various *Estheria*-bearing shales were struck in the respective bores; and, when known, the thickness of the bed, and its height above the highest coal seam met with in each bore.

Name of Bore.	Depth in feet from surface.	Thickness in feet of *Estheria*-bearing shale.	Height above first Coal Seam.	Authority.
	feet.	ft. in.	feet.	
Moore Park	1,523	30 0	.....	Cox
	1,543	283 0	.....	
	1,826	34 0	.....	
Dent's Creek	1,362	1 3	866	David
	1,625	2 1	603	
	1,651	0 6	577	
	1,915	....	313	
	1,932	6 0	296	
	2,000	10 0	228	
Port Hacking	2,160	.....	.....	Cox
Heathcote	1,009	3 0	514	David
Narrabeen	1,961	.....	.....	Coghlan
Liverpool	1,080*	not reached	.....	.....

* Unfinished.

In 1883 I examined at the British Museum (Natural History Branch) some small bivalves forwarded to me by Mr. C. S. Wilkinson, and gave to them the M.S. name of *Unio Wianamattensis*.* These little shells were obtained by Mr. David from ironstone bands in the Wianamatta Shales, where quarried for brick-making purposes at Waterloo and Surry Hills.

Since this important discovery, an exploration of the Wianamatta Shales at Bowral has been made by Mr. B. Dunstan, and has resulted in the unearthing of at least three additional species of bivalve shells.

Finally, if we add to the foregoing the interesting Univalve found at Biloela by Mr. J. H. Maiden, Curator of the Technological Museum, our list of the Invertebrate Fauna of this group of rocks is complete, so far as at present known. The affinities of *Tremanotus Maideni*, Eth., jnr., have been fully pointed out already,† and the interest attached to the reappearance of an obscure Silurian genus dwelt on.

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* See Wilkinson, "Notes on the Geology of New South Wales," 2nd edition, 4to. (Sydney), 1887, p. 76.

† "Annual Report of the Department of Mines of New South Wales for 1886" [1887], p. 174, plate N, figs. 1-3.

II.—DESCRIPTION OF THE SPECIES.

Class.—**CRUSTACEA.**

Order.—**Phyllopoda.**

Family.—*LIMNADIDÆ.*

Genus.—ESTHERIA, *Rüppell* and *Straus*, 1837.
(Mus. Senckenberg. 1837, II, p. 119.)*

ESTHERIA COGHLANI, *Cox*, Pl. 1, Figs. 1–5.

Estheria Coghlani, Cox, Proc. Linn. Soc. N. S. Wales, for 1880 [1881], v, pt. 3, p. 276.

Sp. Char.—Carapace valves oval, but more commonly assuming some modification of that form from distortion. Hinge border straight, but shorter than the valves. Umbones anterior, at the front end of the hinge border. Ventral margin very convexly rounded. Anterior margin rounded below, sinuous above, being excavated under the umbones; posterior margin rounded, insensibly passing above and below into the hinge border and ventral margin respectively. Ornament of rather irregular concentric costa or ridges.

Obs.—It is very difficult to draw up determinate characters for such variable little bodies as *Estheria*. I have here considered the form occurring at Moore Park, as the type of Dr. Cox's species, as that appears to be the one to which he originally applied the name of *E. Coghlani*. The specimens, I regret to say, are not extant; but Figs. 1–5 are taken from the original drawings of his fossils. I take Fig. 1 to represent the correct outline and appearance of the species, whilst in Fig. 2 we have a form more oval in shape, and with a nearly central umbo, which has been thrust or squeezed upwards, and the shell pressed rather obliquely. In Fig. 3 the umbo is equally median, but depressed, and the whole shell has to some extent been obliquely distorted.

I have most carefully compared a number of *Estheria* from the Dent's Creek Bore with these drawings, and notwithstanding an opinion which has

* *Vide* T. R. Jones, Mon. Foss. Estheriæ, 1862, p. 10.

been expressed to the contrary, I cannot see any difference between the former and the illustration Dr. Cox has kindly put at our service. The natural size is identical in both cases, the concentric costa the same, and method of distortion quite similar. The condition most frequently met with is that represented in Figure 4, with the umbo projecting above the hinge border.

I must confess to never having seen the characteristic *Estheria* surface-reticulation on any of the Dent's Creek specimens, but that of those from Moore Park is figured (Fig. 5) from Dr. Cox's drawing. This does not convey a perfectly accurate idea of the ornament of the valves in *Estheria*, but is nevertheless probably correct. When freshly broken core-surfaces are examined, each valve is seen to be covered with a thin pellicle of mineralized matter; but neither this nor the cast below show any trace of the pitted appearance to which one is accustomed in *Estheria*. On the other hand, some examples present a slight, although undoubtedly wrinkled appearance, which may perhaps agree with the wrinkled surface shown in some of Professor T. R. Jones' figures of *Estheria elliptica*.* On the other hand, the possible relation of these little fossils to those small and hardly studied bivalves scattered through the Coal Measures of Great Britain, and more particularly the Calciferous Sandstone Series of Scotland, generally referred to *Anthracomya*, should not be overlooked. On the whole, however, bearing in mind the structure illustrated in Fig. 5, it is more probable that the present fossils are related to *Estheria*.

The size of the valves from the Moore Park and upper horizons of the Dent's Creek borings is remarkably uniform, varying from $1\frac{1}{4}$ to 2 millemetres in the longest diameter of the valves. But those obtained from the 1,915-foot, 1,932-foot, and 2,000-foot beds in the last-named exploration are decidedly larger, measuring from 2 millemetres to as much as 5 millemetres. This difference in size produces a noteworthy alteration in the appearance of these little fossils; and it would not surprise me to find that we have here a second species of *Estheria*. The material, unfortunately, is too limited in quantity to permit of more than a passing notice, with a figure for future reference.

The examples from the Narrabeen Bore are but fragmentary, but I believe them to be of the type just referred to. If so, coming from a depth of 1,961 feet, they will tend to bear out the supposition that a second species exists.

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* Mon. Foss. Estheriæ, Pal. Soc., 1862, t. 3, Figs. 21 and 22.

As previously stated, *Estheria* have been obtained from the cores of the Heathcote Bore, but they have not come under my notice; neither have those said to have been found in the unfinished bore at Liverpool.

The frequent distortion of the valves from the Moore Park and higher horizons in the Dent's Creek Bore renders comparison with hitherto described species difficult, but if we regard Fig. 1 as a typical outline of *E. Coghlani*, it accords better with one of Professor Jones' figures of the Triassic *E. minuta** than with any other known to me.

Localities.—1, Moore Park Bore, Baptist's Gardens, Bourke-street, Surry Hills, Sydney *(Dr. J. C. Cox)*; 2, Botany Bore, Holt-Sutherland Estate, Port Hacking *(Dr. J. C. Cox)*; 3, Dent's Creek Bore, Holt-Sutherland Estate, George's River *(T. W. E. David, Esq., B.A., &c.)*

Horizon.—*Estheria* Shales, above productive Coal Measures (see table, p. 4).

Collection.—Only those examples from the Dent's Creek Bore are in the Mining and Geological Museum.

Class.—**PELECYPODA.**

Order.—**Unionacea.**

Family.—*UNIONIDÆ.*

Genus UNIO.—*Retzius*, 1788.
(Dissertatio Hist. Nat. p. 16.)

Obs.—The shells found by Mr. David at Waterloo and the Surry Hills are provisionally referred to the genus *Unio*. I am able to detect several important characters of this genus, whilst others of equal significance have not been noticed. Either this is due to the state of preservation of the specimens, or from the fact that they may belong, not to *Unio*, but an allied genus. The Unioniform shells of the Palæozoic Rocks are usually referred to *Carbonicola*, M'Coy, and *Anthracosia*, King; but in the present remains the distinguishing features of these genera are not apparent. Four species

* Mon. Foss. Estheriæ, Pal. Soc., 1862, t. 12, f. 1.

of the Unionidæ only have up to the present time been described from Australian and Tasmanian sedimentary deposits. *Unio Dacombii*, M'Coy, was discovered in the Mesozoic Carbonaceous Series of the Wannon River, Victoria; but I believe only "one doubtful specimen" exists.* The other three forms are Tertiary species, one *Unio Witkinsoni*, Eth. jnr.,† from the Tertiary Deep Leads of Gulgong; the others from the Upper Tertiary beds of Launceston, Tasmania, viz., *Unio Johnstonii*, Eth., jnr.,‡ and *Anodonta (?) Tamarensis*, Eth., jnr. The forms from the Wianamatta Shales are certainly distinct from all of these. In Europe, *Unio* is usually regarded as characteristic of higher Jurassic beds, its place in the lower series being taken by *Cardinia*. Dr. A. von Klipstein, however, has described under the name of *Unio (?) problematicus*,§ a shell from the Alpine St. Carsian Series (Upper Trias), having much the external appearance of a nasute *Unio*. The earliest known form of this genus in the sedimentary rocks of North America, on which any reliance can be placed, is *Unio Cristonensis*, Meek. In his most excellent paper, "A Review of the Non-marine Fossil Mollusca of North America,"‖ Dr. C. A. White says, "The earliest known members of that family¶ now known to exist in North American strata are two or three species, specimens of which were collected by Professor E. D. Cope, in the valley of Gallinas Creek, New Mexico, from strata which he regarded as of Triassic age. These shells belong unquestionably to the genus *Unio* proper, as is shown by the character of the hinge, and the muscular markings. . . One of these forms, . . . was described by Mr. Meek, under the name of *U. Cristonensis*. . . . . There are some reasons for regarding the strata from which these shells were obtained as of Jurassic instead of Triassic age; but further investigation is needed before such an opinion can be confidently expressed."

In the present case we see the general outline of *Unio*, and the eroded beaks found in so many of its species. On the other hand, the nature of the hinge in these little shells is at present unknown.

A second species, found by Mr. B. Dunstan, at Bowral, approaches even closer in outward form to some species of *Unio* than the present shell. It is described as *Unio Dunstani*.

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* Geological Survey Victoria, Progress Report, 1874, p. 24.

† *Unio Aucklandicus*, var. *Wilkinsoni*, Annual Report, Department of Mines, New South Wales for 1878 [1879], p. 168. T. 3, f. 5.

‡ Papers and Proc. R. Soc. Tasmania, for 1880 [1881]; p. 18.

§ Mittheil. Gebiete Geol. u. Pal., 1845, ii, p. 265, t. 17, f. 25 *a* and *b*.

‖ Third Ann. Report U. S. Geol. Survey (Powell's), 1881-2 [1883], p. 425.

¶ *i.e.*, the Unionidæ.

Unio (?) Wianamattensis, *Eth., jnr.*

Pl. II, Figs. 1–4.

Unio Wianamattensis, Etheridge, jnr. (M.S.), in Wilkinson, "Notes, Geology New South Wales," second edition, 1887, p. 76.

Sp. Char.—Shell ovate-obliquely oblong, laterally compressed, thin. Dorsal margin, or hinge line, straight posteriorly, angulated at the anterior end, but in its entire length not as long as the shell; ligament small, and projecting but little above the dorsal margin. Ventral margin nearly straight, with a slight sinus at the middle. Anterior end small, very much compressed, and with the margin rounded; posterior end compressed, the margin obliquely truncated. Umbones small, obtuse, and ill-defined, sometimes eroded; diagonal ridge well-marked, although not strong; the flanks of the valves decrease rapidly in convexity from this ridge to the ventral margin, but an almost imperceptible sinus traverses them upwards from the ventral marginal inflection. Posterior slopes small, steep, and not concave. Internal characters of the cardinal margin unknown. Pallial line not deeply impressed. Small, deep, muscular pits, more or less arranged in a semicircle, occupy the umbonal cavity; anterior and posterior adductor impressions unknown. Surface with fine concentric ridges, subdivided by distant subimbricating growth laminæ, the whole covered with a very regular and beautiful microscopically and longitudinally wrinkled epidermis.

Obs.—Although the reference of this species to *Unio* is only provisional, it yet recalls to mind many characteristic species of this genus in the general outline of its shell.

The compressed valves, bent anterior cardinal margin, rounded diagonal ridge, and sharp ends will at once serve to distinguish it from other species which may at any future time be met with at a similar horizon. The disjointed and delicate transverse wrinkling of the epidermis is a very important character in *U. (?) Wianamattensis*, and gives to the shell a peculiarly smooth and glossy appearance. It covers the whole of the valves from the umbone to the ventral margin, and it appears to me to be a truly epidermal character, and in no way connected with the shell structure. It must not in the least be mistaken for the irregular wrinkling, or rather crumpling, met with in many papyraceous-shelled mollusca of the Carboniferous rocks in other parts of the world, such as seen in the genera *Anthracomya*, *Naiadites*, and the like.

The shell of *U. (?) Wianamattensis* was evidently thin, and it necessarily follows that the eroded beaks do not present that marked feature, usually so characteristic of a few families of Pelecypoda, particularly the Unionidæ.

Locality.—Messrs. Goodlet and Smith's Brick-clay Quarries at Crown-street, Waterloo, and Surry Hills, Sydney.

Horizon.—Ironstone bands in the Wianamatta Shale.

Collector.—T. W. Edgeworth David, Esq., B.A., &c., Geological Surveyor.

Unio Dunstani, *sp. nov.*

Pl. I, Figs. 11–19.

Sp. Char.—Shell narrow, very transversely elongated, thin and compressed throughout its length, approaching to linguliform. Cardinal margin long and slightly arched, ventral margin comparatively straight, sharp and knife-edge like. Anterior end very much compressed, the margin rounded, posterior end thin, attenuated, and very much compressed towards the margins, which are obliquely rounded, the posterior-ventral angle being almost pointed. Umbones placed close to the anterior end, small, and laterally flattened; flanks of the shell almost flat; diagonal ridges and posterior slopes but very faintly developed, the latter very faintly concave, and lost in the compressed posterior end. Anterior adductor impression fan-shaped, situated very high up under the anterior cardinal margin; umbonal scars very strongly marked, two immediately behind the adductor scars in a line, and close under the cardinal margin, the others clustered on the flank; posterior adductors faint and shallow. Pallial line well marked, with the impression of fibre scars at the anterior end. Ornament of very closely set concentric lines, with irregular glossy growth laminæ.

Obs.—This is so very distinct from the other shells here described that a comparison is not required. It possesses the unmistakable outline of one section of the genus *Unio*, represented by such forms as *Unio Grayanus*, Lea, *U. Shepardianus*, Lea, and *U. folliculatus*, Lea. There is also some resemblance to a European Coal Measure fossil, *Anthracosia lateralis*, Brown,*

* Ill. Foss. Conchology, 1849, p. 177, t. 73, f. 26.

but it is too flat and linguliform to be intimately compared with that species. This is an exceedingly plentiful shell at Bowral, and in company with *U. Bouralensis* enters extensively into the formation of the ironstone bands at that locality.

Locality.—Railway cutting near Gibraltar Tunnel, Bowral, Co. Camden.

Horizon.—Ironstone bands in the Wianamatta shale.

Collector.—Mr. B. Dunstan, after whom I have much pleasure in naming this interesting species.

Genus UNIONELLA, *gen. nov.*

Gen. Char.—Shell quadrangular to irregularly trapeziform, equivalve, inequilateral; umbones depressed and contiguous, eroded; ligament external; cardinal teeth apparently one in each valve; no lateral teeth; anterior adductor impression single, bounded posteriorly by an oblique ridge; posterior adductor impression single and inconspicuous; supplementary umbonal muscular scars pit-like, either forming a semicircular line, or clustered; pallial line simple.

Obs.—This genus has been instituted for the reception of small bivalves collected by Mr. B. Dunstan at Bowral. The undoubtedly eroded condition of the umbones indicates either the Unionidæ or the Cyrenidæ as their natural resting-place; but with no genus in either of these families do they otherwise seem to agree. The single condition of the adductor muscular impression, and the faintly marked state of the posterior clearly separate the present shells from *Unio*, to which they are again, however, related through the umbonal muscular scars, and the exterior ligament. The absence of lateral teeth, which I believe do not exist in the present genus, shows a transition towards *Anodonta*; but there are no other characters in common. Unfortunately for classificatory purposes, the acknowledged genera of the Unionidæ are established on such limited characters as to render them practically useless, especially when such minute questions as generic comparison are entered on.

The hinge structure, although not wholly known, is still sufficiently apparent to separate *Unionella* from any of the Cyrenidæ. I have not been able to actually isolate a hinge line, but in numerous cases where the umbones have been dissolved, and the anterior end of the shell decorticated, we are

presented with the features seen in Pl. II, fig. 12. Posterior to the umbones it will be observed the hinge is perfectly straight; but in front of them there is a constant flexure, or double flexure, which seem to indicate the presence of cardinal teeth. I cannot, however, account for this appearance in any other way.

In *Unio* the anterior cardinal teeth are 1—2, or 2—2; but in some robust species the 1—2 arrangement appears to become reduced to 1—1. In such instances there is probably little difference between a dental formula of this nature and the structure observed in the Bowral shells.

The eroded state of the umbones is very marked in both the typical species, so much so in some individuals as to almost expose the interior cavity of the shell, and render the umbonal muscular scars outwardly perceptible.

Type.—Unionella Bowralensis, sp. nov.

Unionella Bowralensis, *sp. nov.*

Pl. I, Figs. 21–23; Pl. II, Figs. 8–14.

Sp. Char.—Shell short, somewhat nasute, moderately convex, compressed and rather sharply produced posteriorly. Cardinal margin to some extent arched, ligament small, short; ventral margin slightly convex. Anterior end shorter and much more gibbous than the posterior; margin rounded. Posterior end small, obtusely pointed; margin rounded, obliquely so above. Umbonal region and body of the shell gibbous, and rapidly declining to the ventral margin. Umbones depressed and inconspicuous, at times much eroded; diagonal ridge rounded, inconspicuous; posterior slope hardly differentiated from the general body of the shell. Anterior adductor impressions deep; umbonal scars extending in a line from the anterior adductor into the umbonal cavity, and there clustered. Ornament of fine concentric lines, with distant laminæ of growth.

Obs.—This, the most abundant form at Bowral, is distinguished from the succeeding species by its much shorter and nasute outline. The cardinal margin is shorter, and the upper part of the posterior margin more obliquely directed. The flanks of the shell also appear to be more evenly rounded.

Locality.—Railway Cutting, near Gibraltar Tunnel, Bowral, Co. Camden.

Horizon.—Ironstone bands in the Wianamatta Shale.

Collector.—Mr. B. Dunstan.

Unionella Carnei, *sp. nov.*

Pl. I, Fig. 20; Pl. II, Figs. 5–7.

Sp. Char.—Shell quadrangular-oblong, longer than high, thick, produced posteriorly. Cardinal margin long, erect, and straight, but not as long as the shell; ligament small, short. Ventral margin straight. Anterior end small, the margin rounded; posterior end produced, somewhat obliquely truncated, and slightly produced ventrally. Umbonal region and body of the shell towards the posterior broad and gibbous; umbones depressed and rather incurved, usually very much eroded, placed at about one-fourth from the anterior end; diagonal ridge very prominent and strongly marked. Sharp towards the umbones; posterior slope wide and flattened, or inclined to the concave, becoming straight-walled under the erect cardinal margin. Anterior adductor impression elongately triangular, strongly marked; posterior impression on the diagonal ridge; umbonal scars similar to those of the last species, and very strongly marked. Ornament consisting of very fine regular lines, with distant laminæ of growth, but the former sharply sinuous, or deflected in the region of the anterior adductor.

Obs.—The quadrangular outline, erect and straight hinge line, and very marked diagonal ridge are characters not met with in the preceding species.

A peculiar inflection of the fine ornamenting lines of the surface is observable in *U. Carnei*. In front of the pronounced anterior cardinal muscular scars, the strong ridge separating the latter from the body of the shell is represented outwardly by a slight depression of the surface or sinus. In passing over this, the fine linear ornament is waved or inflected, and becomes a very important feature of this species. Sometimes it is very marked, at others faint, but invariably present in one form or the other.

I have much pleasure in associating with this the name of Mr. Joseph E. Carne, Curator of the Geological and Mining Museum of this Department.

Locality.—Railway Cutting, near Gibraltar Tunnel, Bowral, Co. Camden.

Horizon.—Ironstone bands in the Wianamatta Shale.

Collector.—Mr. B. Dunstan.

Class.—**GASTEROPODA.**

Order.—**Prosobranchiata.**

Family.—*BELLEROPHONTIDÆ.*

Genus.—TREMANOTUS, *Hall*, 1867.

(20th Annual Report, Regent's Univ., New York State Cab. Nat. Hist., 1867, p. 247.)

TREMANOTUS MAIDENI, *Eth., jnr.*

Pl. II, Figs. 15–17.

T. Maideni, Etheridge, jun., Ann. Report Dept. Mines, N. S. Wales, for 1886 [1887], p. 174. App. N., plate.

Sp. Char.—Shell discoidal, strongly trumpet-shaped, thin; whorls five or more, visible on both sides, elliptical in section, the last one sub-angular at the sides, but the inner whorls with the flanks much more rounded; apertural expansion much prolonged upwards, but not greatly expanded laterally; the anterior or outer lip reflected backwards, and the slit, if present, not visible from imperfection of preservation; inner lip apparently not much reflected; siphonal openings numerous, close together, oval, and situated on rather raised oblong prominences, which give to the periphery a rather broken-keeled appearance; surface of shell ornamented with spiral fluctuating lines, parallel to the dorsal keel, and which on the expanded outer lip become coarser and more plait-like. Length, 4 in.; breadth, 2 in.

Obs.—*T. Maideni* was described in the last Annual Report of the Department, when the following remarks were made on it:—

"The shell in question may belong to either one of two genera—*Bucania*, Hall, or *Tremanotus*, Hall—precisely as certain points in its structure are interpreted. Both these genera are members of the extinct family Bellerophontidæ, and nearly allied to *Bellerophon* itself. The family became extinct at the close of the Palæozoic Period, with the exception of one genus, *Bellerophina*, which appeared and died out in the Cretaceous Epoch. If the present shell is determined to be a *Bucania*, we have here simply a survival from the underlying Carboniferous rocks, at the termination of which period the genus ceased to exist. On the other hand, should the controversial point of structure, shortly to be touched upon, be maintained in favour of *Tremanotus*, we cannot help regarding the Hawkesbury fossil as a very interesting reappearance of a peculiar Upper Silurian type of Gasteropoda.

Tremanotus occurs in the Niagara Group of North America, and in the equivalent horizon in Europe, the Wenlock Series; and although *Bucania* is not known in Australian Carboniferous rocks, notwithstanding its otherwise wide geographical range, representatives of the family Bellerophontidæ are found in the Upper Marine Series of New South Wales.

"The view of Dr. O. Feistmantel as to the Triassic age of the Hawkesbury Series appears to be now generally accepted, based on the nature of its flora, and has been adopted by Mr. C. S. Wilkinson.* Accepting this view as probably the correct one, so far as our knowledge of the Hawkesbury flora at present exists; and, looking to the firmly established position of the group of beds above the Carboniferous Series, we are constrained to regard the occurrence of *Tremanotus* in the Hawkesbury Sandstone as a reappearance of a member of the Bellerophontidæ, similar to that of the little *Bellerophina* in the Cretaceous Period. I do not otherwise perceive how it is to be accounted for, when we remember that the Carboniferous fauna, of which the Bellerophontidæ form an important factor, died out at the close of the Upper Marine Series, almost completely, and that between this horizon and that of the Hawkesbury rocks we have the whole of the Upper Coal Measures without an invertebrate fauna. With the view of arriving at a more accurate conclusion, let us examine the characters of the two genera more minutely. *Bucania* was established† by Professor James Hall, of Albany, 'to include several species of shells of a peculiar form, usually referred to *Bellerophon*, but from which they differ in having all the volutions visible, and gradually increasing in size..... The *Bellerophon carinarietes*, of Sowerby (Min. Conch., Tab. 169, f. 2) will fall under this genus.' The name is derived from *βυκανη*, a trumpet, which exceedingly well exemplifies the form of the shell, the whorls enlarging rapidly, with an expanded aperture, the last one being carinate along the median line of the back. *Tremanotus* is described thus‡ by the same author: 'Volutions apparently in the same plane; umbilicus on both sides; aperture expanded; the dorsal line piereed by several oblong perforations.' On the species *Tremanotus alpheus* he remarks: 'The specimen is a cast of the interior of the shell, and along the periphery presents a range of elongated oval prominences which have apparently been perforations in the shell, arranged at equal distances from each other.' Now, a comparison between the characters of the two genera and those of the Hawkesbury fossil

* Official Record, Sydney International Exhibition, 1879 (1881), pp. 56 and 64; N. S. Wales Official Catalogue, Colonial and Indian Exhibition, 1886, p. 166.

† Pal. New York, 1847, 1, p. 32.

‡ 20th Annual Report, Regent's Univ. State New York, Cabinet Nat. Hist., 1867, p. 347.

will indicate its resemblance to *Tremanotus* rather than to *Bucania*. In all three the volutions are in the same plane, there is an umbilicus on both sides, and a much expanded trumpet-shaped aperture; but in *Bucania* the back of the body whorl is simply carinate, whereas both in *Tremanotus* and the Hawkesbury shell the carina bears traces of a series of oval apertures extending along its course—a very important structural difference. An inspection of the accompanying sketches will at once illustrate these distinctive features. The opinion has been advanced by Mr. S. A. Miller* that the "supposed openings on the cast represent the spines upon the back of the anterior part of the last whorl of the shell, and the fossil is a true *Bucania*."

"On the other hand, the late Mr. F. B. Meek, in an able article, 'Note on the affinities of the Bellerophontidæ,'† used the row of isolated oval openings in *Tremanotus* as an argument for placing the family amongst the Prosobranchiate Gasteropoda. He says: 'Now, as we have no examples, so far as known to the writer, either amongst the Heteropoda or Cephalopoda, living or extinct, of a shell with isolated siphonal openings, while we have many such examples amongst the Prosobranchiate Gasteropoda—such, for instance, as in the Haliotidæ, Fissurellidæ, and Pleurotomariidæ—the bearing this feature in the newly discovered type has on the question respecting the affinities of the Bellerophontidæ will be readily understood. In other words, it indicates for the family a position near the Fissurellidæ and Haliotidæ, and between those groups and the Pleurotomariidæ.' Again he adds: 'It will be seen that the shell under consideration *(i.e., Tremanotus)* presents exactly the form of *Bucania*, from which it only differs in the peculiar and interesting character of having along the middle of the dorsal side a row of isolated oval siphonal openings.'

"It is manifest from these remarks that Mr. Meek did not for a moment regard the markings on Professor Hall's *Tremanotus* as 'casts representing the spines on the back of the outer part of the last whorl,' as suggested by Miller, but rather as genuine siphonal openings. If any further proof is wanting, it can be obtained by an inspection of the beautiful figures of *Tremanotus longitudinalis*, from the Wenlock beds of Gotland, given by Dr. G. Lindström,‡ in which the shelly matter of the mollusc has been retained, and the siphonal openings preserved in great perfection. Even a little more attention on Mr. Miller's part to American palæontological literature

* Cat. American Pal. Foss., 2nd Edit., 1885, p. 304.
† Proc. Acad. Sci., Chicago, 1886, I, p. 11.
‡ Kongl. Svenska Vet.-Akad, Handlingar, 1884. Bd. xix heft. 2, No. 6, p. 86, t. 4, f. 1-7.

would probably have convinced him that these markings were not spines. In the 'Geology of Canada,' the late Mr. Billings figured* an example of *Bellerophon angustata*, Hall, in which the siphonal openings are even better shown than in Professor Hall's original delineation of *Tremanotus*, extending along the whole of the middle line of the back of the last whorl. Mr. Miller refers *Tremanotus alpheus*, Hall, to *Bucania Chicagoensis*, M'Chesney; but although Professor M'Chesney included his figures† of the former under the name of the latter, he was careful in his revised paper† to point out that they really represented *Tremanotus alpheus*, and the casts of the apertures are distinctly visible. Siphonal openings occupying this position are not alone confined to *Tremanotus* in the Bellerophontidæ. For instance, in the genus *Salpingostoma*, F. Roemer,‡ from the Lower Silurian Boulder Drift of East Prussia, a single long slit-like aperture occurs on the median line of the back in a similar manner to the oval and more numerous one of *Tremanotus*. Lastly, in the genus *Tubina*, Barrande,§ from the Upper Silurian Series of Bohemia, the periphery is ornamented with a row of apertures and an additional row on each side flanking the median series, all extended into curved hollow spines.

"Accepting, therefore, the united opinions of Messrs Meek and Lindström in favour of retaining *Bucania* and *Tremanotus* as separate genera, it necessarily follows that the Hawkesbury fossil has a greater affinity with the latter than the former. Furthermore, it must also be admitted that we have here a most interesting reappearance of a genus supposed to have closed its existence during the Upper Silurian."

This unique shell is quite distinct from either of the Gotland species, but is nearer to *T. alpheus*, Hall, or *T. angustata*, Hall, as figured by Billings, agreeing with the former especially in the broad plait-like ribbing on the back of the outer lip, and the apparent absence of much lateral expansion of the same.

Locality.—New Government Docks, Biloela, Sydney.

Horizon.—Hawkesbury Sandstone, at a depth of 25 feet from the surface, in a matrix of limonite.

Collector.—J. H. Maiden, Esq., Curator of the Technological Museum, after whom the species is named.

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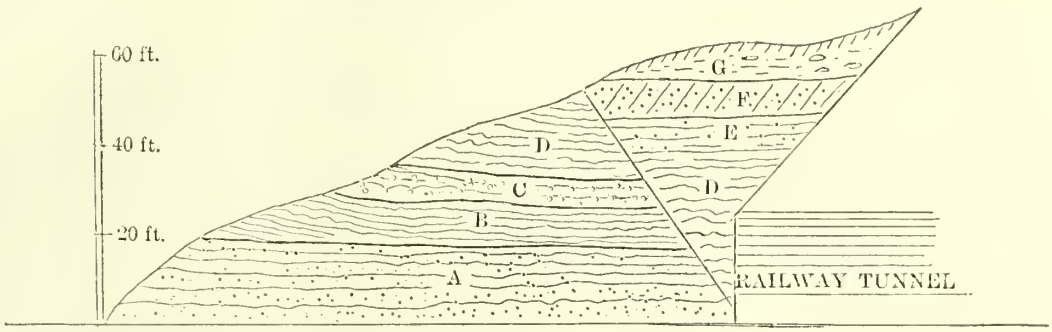
* Geol. Canada, 1863, p. 344, f. 352.
† Illustrations of New Palæozoic Fossils, 1865, t. 8, f. 4 *a-b*.
‡ Lethaea Geognostica, Theil 1, Atlas, 1876, t. 5, f. 12 *a* and *b*.
§ Owen's Palæontology, 1860, p. 71, f. 17 (8).

III.—GEOLOGICAL NOTES ON THE BOWRAL LOCALITIES.

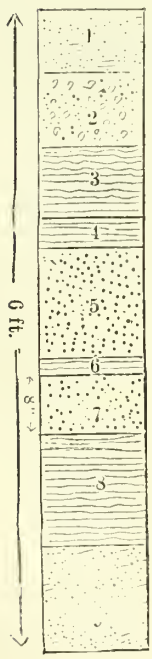
Mr. B. Dunstan, the collector of the Labyrinthodonts and fish remains, plants, and shells found at Bowral, has been kind enough to furnish the following notes on their geological occurrence :—

"Position of strata in the Wianamatta Shales, in which the remains of Labyrinthodonts, fish, shells, and plants were found at Gibraltar Tunnel, Bowral, near Mittagong."

Gibraltar Tunnel, near Mittagong Section, at the Northern End of the Tunnel, where *Cleithrolepis* and Branches of Fossil Plants were Found.



A.—Sandstone containing clay and shale bands.
B.—Dark shale.
C.—Fine-grained sandstone alternating with conglomerate and shale bands.
D.—Dark shale, with clay bands about one inch thick running very regularly through it.
E.—Sandstone layer.
F.—Very irregular sandstone.
G.—Dark shale, with clay bands and nodules.

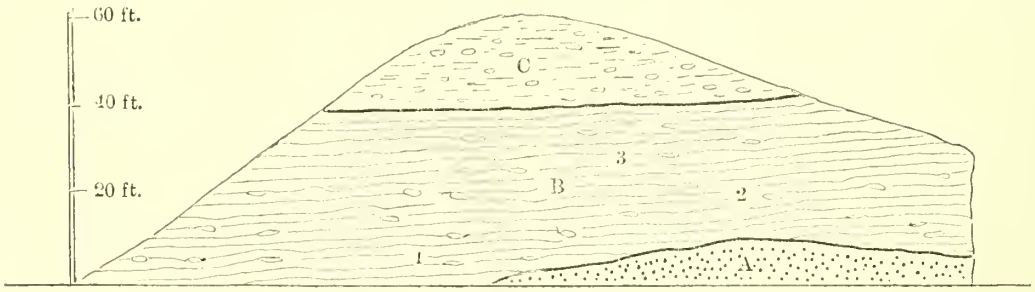


Section of Bed C.

1. Irregular layers of sandstone.
2. Ironstone conglomerate.
3. Iron-clay band.
4. Shale band.
5. Fine-grained sandstone.
6. Shale band.
7. Sandstone, where *Cleithrolepis* was found.
8. Shale band, very dark.
9. Sandstone, between which and (8) *Phyllotheca* stems were found.

"Nearly all the sandstones are calcareous, especially those at F, and below this bed, in the face of the cutting, the stratification is obscured by calcareous tufa deposited from the dripping water. Fossil plant remains are found, either in, or just above or below the clay bands, or else in the fine-grained sandstones, and are absent from the dark, fine-grained shales. The strata are almost horizontal, in no place exceeding a dip of 5°, the strike being about E. and W."

Section in Cutting near Gibraltar Tunnel.



Strata horizontal.

A.—Soft sandstone.

B.—Dark shales containing nodules, in which the fossil fish and plants were found.

C.—Light coloured shales containing soft clay bands and small nodules, in which were found imperfect impressions of plants. The nodules generally were found to contain a nucleus of stems of plants. In one case the nodule had formed round a piece of selenite (gypsum).

"The nodules in Bed B are distributed throughout the whole of the bed, but those containing the fish were found, principally, near the top. At place marked (1) I found a block weighing about 1 cwt. containing numbers of *Unio* shells (both large and small ones), and in breaking some of the shells they were found to contain water.

"At the point marked (2) part of the remains of a Labrynthodon (now in Museum) were found. At the place (3) occurred a large fish in a very large nodule (much broken). The other fish I found above (3) and close to Bed C."

INDEX TO THE GENERA AND SPECIES DESCRIBED.

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EXPLANATION OF PLATE I.

Page

ESTHERIA COGLANI, *Cox.* 6

Fig. 1. Lateral view of the normal form.

Fig. 2. A similar specimen, obliquely crushed, and with the umbo produced.

Fig. 3. An individual pressed from above, with the umbo rather displaced.

Fig. 4. Two valves crushed together, illustrating the manner in which the *Estheriæ* occur

Fig. 5. Surface ornament, highly enlarged.

Figs. 1–5 are from drawings of specimens from the Dent's Creek Bore, and supplied by Dr. J. C. Cox; magnified about 10.

ESTHERIA (?), *sp.*

Fig. 6. Lateral view of an indistinct valve, from 1,483 ft., in the Dent's Creek Bore x 5

Fig. 7. An obliquely pressed and distorted valve from a depth of 1,915–1,955 ft. in the same bore... ... ... x 4

Fig. 8. Another example which has assumed a triangular form 1,932 ft. in the same bore ... ... x 5

Fig. 9. Portion of an indistinct valve, distorted into a triangular or deltoid outline, from 2,000 ft. in the Dent's Creek Bore ... ... x 5

Fig. 10. Fragment of a valve from a depth of 1,961 ft. in the Narrabeen Bore ... x 5

UNIO DUNSTANI, *Eth., jnr.* 11

Fig. 11. Lateral view of a small specimen showing the long hinge and muscular scars x 2

Fig. 12. Dorsal view of the same specimen, exhibiting the relative thickness of the internal cast ... ... x 2

Fig. 13. A much larger example, with portions of the shell remaining ... ... x $\frac{1}{2}$

Fig. 14. Dorsal view of Fig. 13 ... ... x $\frac{1}{2}$

Fig. 15. A larger and somewhat more robust individual, with portions of the shell still retained ... ... x $\frac{1}{2}$

Fig. 16. Dorsal view of the same ... ... x $\frac{1}{2}$

Fig. 17. A specimen in which the anterior adductor impression is visible, and the umbonal scars faintly indicated ... ... x 2

Fig. 18. Dorsal view of the same ... ... x 2

Fig. 19. A small shell in which the extreme attenuation of the shell towards the posterior end is shown ... ... x $\frac{1}{2}$

Figs. 11–19 are from Bowral Specimens.

UNIONELLA CARNEI, *Eth., jnr.* 14

Fig. 20. Side view of an imperfect specimen crushed from above; Bowral ... x 2

UNIONELLA BOWRALENSIS, *Eth., jnr...* 13

Fig. 21. Portion of two valves obliquely pressed from above ... ... x 3

Fig. 22. Dorsal view of another individual, showing the thickness of the valves, and the ligament ... ... x 3

Fig. 23. A mass of ironstone with valves of *Unionella Bowralensis*, and *Unio Dunstani* scattered through it.

Figs. 21–23 are from Bowral specimens.

EXPLANATION OF PLATE II.

Page

Unio (?) Wianamattensis, *Eth., jnr.* 10

Fig. 1. Lateral view (the dotted dorsal margin is not straight enough) ... ... x 2

Fig. 2. Dorsal view, with the hinge, ligament, and proportionate thickness ... x 2

Fig. 3. Portion of the surface ornament ... ... x 4

Fig. 4. Another specimen, crushed, and the umbo to some extent pinched up ... x 2

Figs. 1–4 are from Waterloo specimens.

Unionella Carnei, *Eth., jnr.* 14

Fig. 5. Lateral view, in which the straight dorsal or cardinal margin is visible ... x 2

Fig. 6. Dorsal view of the same, showing the prominent umbonal or diagonal ridge, and the relative convexity of the valves ... ... x 2

Fig. 7. Lateral view of another example ... ... x 2

Unionella Bowralensis, *Eth., jnr.*... 13

Fig. 8. An internal cast, lateral view, showing the impression of the ridge bounding the anterior adductor on its posterior side... ... ... x 3

Fig. 9. The united valves viewed partially from above, with eroded umbones ... x 3

Fig. 10. Dorsal view of a small example, illustrating the general convexity of the valves and thickness of the test ... ... x 3

Fig. 11. A small specimen, with the cavity of the ridge bounding the anterior adductor impression, and the umbonal muscular scars visible ... ... x 3

Fig. 12. Dorsal margin of a cast showing the inflection of the hinge line ... ... x 2

Fig. 13. A large and very nasute variety showing the umbonal scars ... ... x 2

Fig. 14. Dorsal view of the same ... ... x 2

Figs. 5–7, 8–14 are from Bowral specimens.

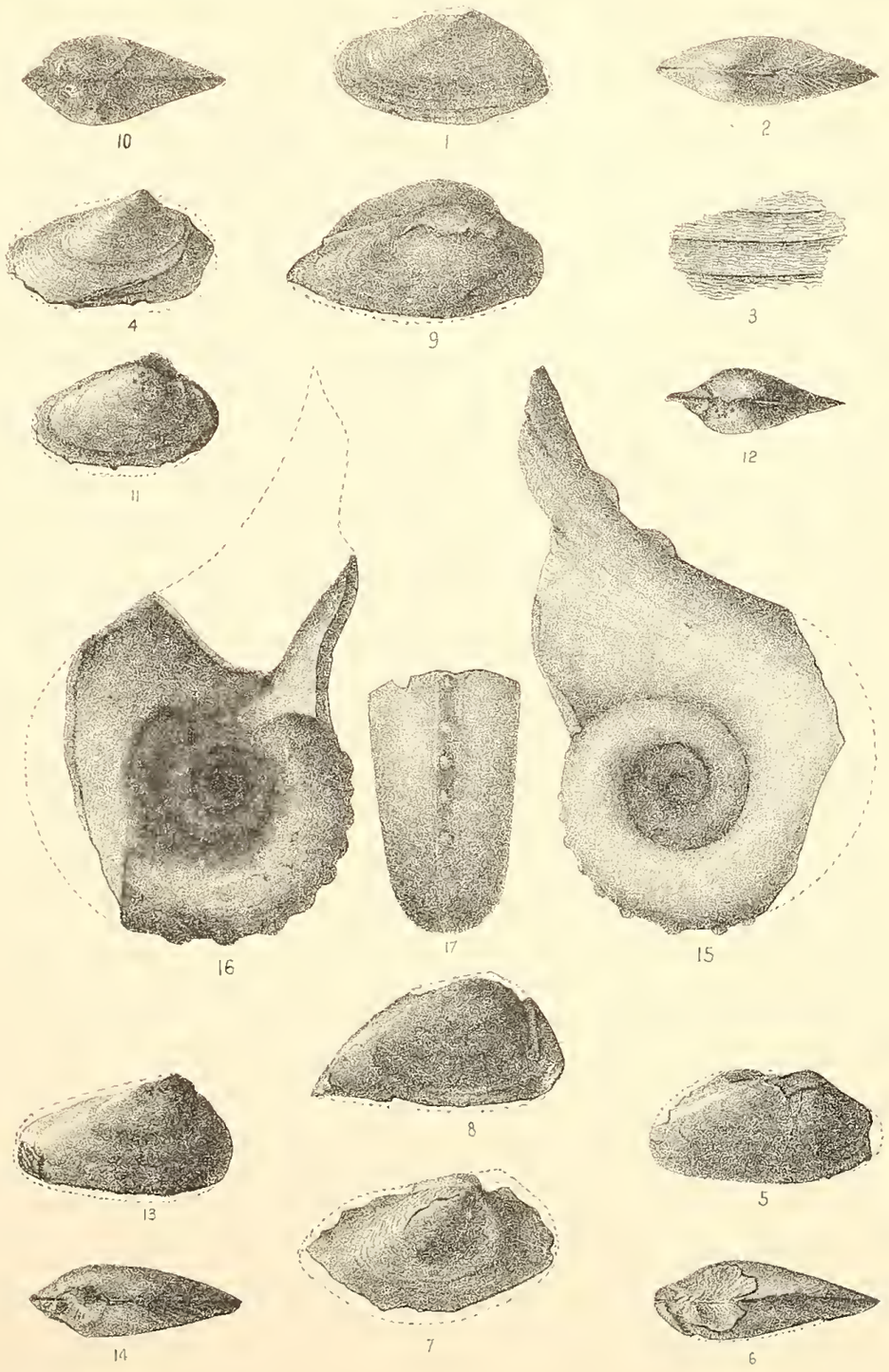
Tremanotus Maideni, *Eth., jnr.* 15

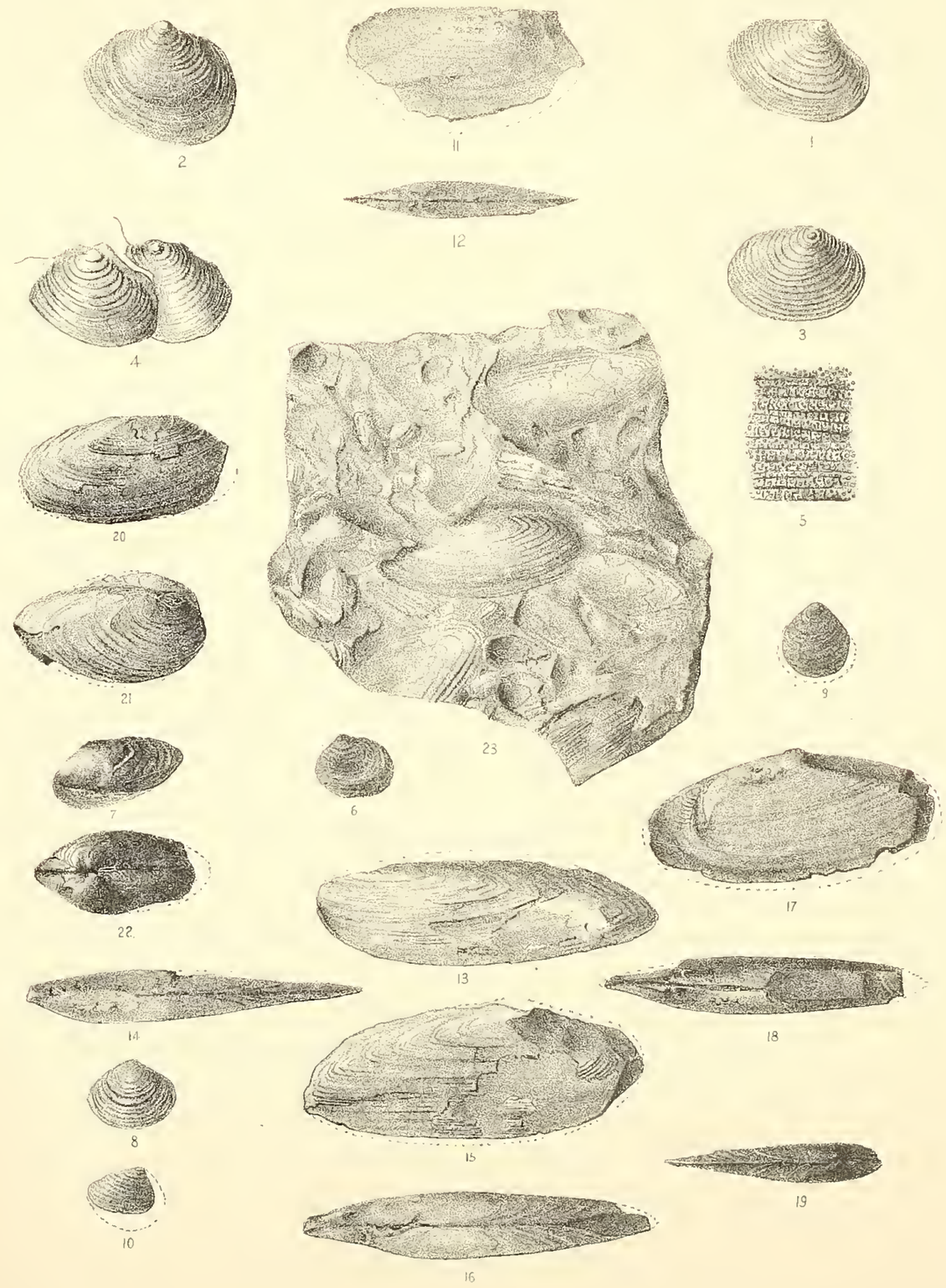
Fig. 15. Lateral view, with the trumpet-like mouth and peripheral apertures.

Fig. 16. The opposite side, showing traces of spiral striæ.

Fig. 17. Front view of last whorl, with the peripheral apertures.

Figs. 15–17 of the natural size are from the Biloela specimen.





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HAWKESBURY_WIANAMATTA INVERTEBRATA.

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